We have all seen examples of deteriorating concrete. In some cases the trouble can be traced directly to a poor quality of concrete, but frequently good concrete is subjected unintentionally to conditions which lead to its rapid disintegration. When this occurs, the owner is understandably upset and the contractor may find himself receiving unpleasant criticism which might have been avoided had both parties been aware of the limitations of the material with which they were working.

This article points out some of the conditions which may be damaging to concrete and indicates precautionary measures that can be taken. No attempt is made to completely cover the field of substances that corrode concrete. Rather, emphasis is placed on some of the more frequently encountered attacking agencies and suggestions made as to how concrete may be protected from them.

AGENCIES THAT ATTACK CONCRETE

DISINTREGRATION OF CONCRETE can occur even though all of the well known principles for producing quality concrete are followed closely, including (1) use of an appropriate water-cement ratio; (2) use of aggregates properly graded and selected for strength and durability; (3) thorough mixing; (4) proper handling and placing and (5) adequate curing. In some cases, concrete of uniform high quality is all that is needed to resist an attacking agent, but in others special surface treatments are essential.

Materials for surface treatments can be obtained to resist any degree of concentration, and final selection is frequently based on secondary considerations such as color, taste, odor, temperature and resistance to abrasion. Color may be important if the treated surface is to be exposed to public view; odor and taste, if food or beverages are involved as in wine storage vats. Because most chemical reactions are more rapid at high temperatures, the type of protection required varies with temperatures encountered. Also, some treatments function only at moderate temperatures or when left relatively undisturbed, but will break down at high temperatures or under the abrasive action of traffic. Finally, cost is a consideration but a treatment having low first cost is not necessarily economical if it offers protection for only a short period of time.

ACIDS

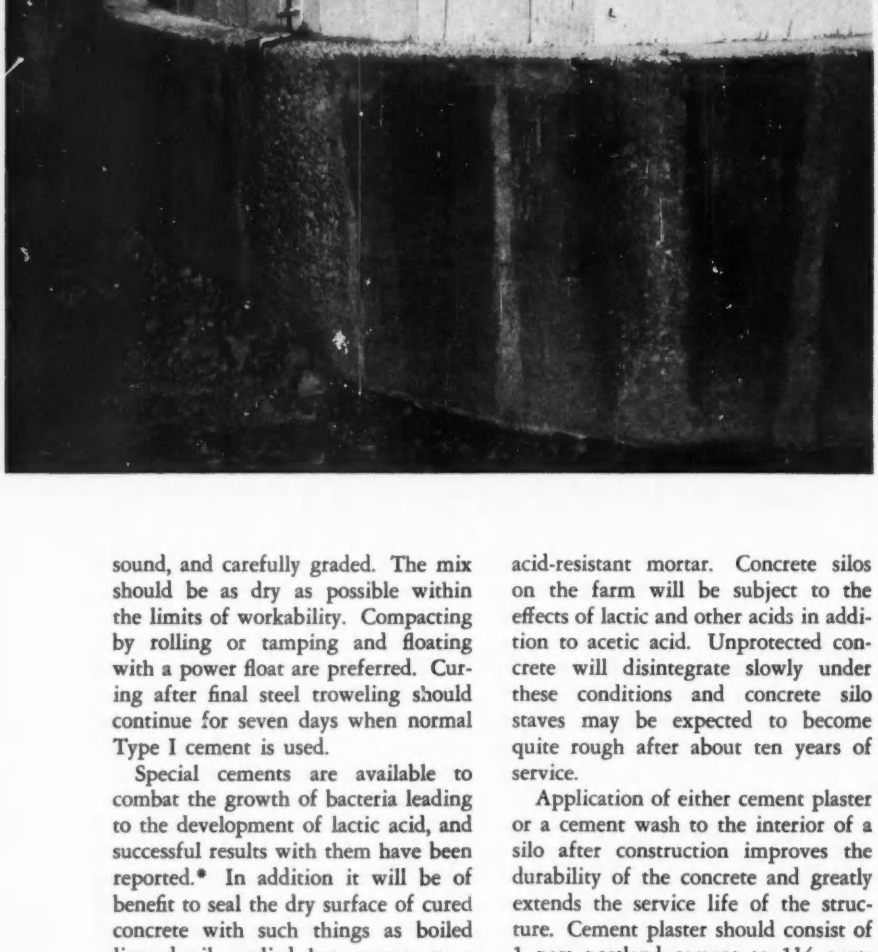
Concrete is not resistant to acids because the calcium it contains is attacked by them. Industries make use of numerous acids, but because their presence is known they can be handled properly. Hidden acids, such as those produced by bacteria growth, are frequently more damaging. Among those encountered in this way are lactic acid, acetic acid, and acids present in fresh or deteriorated vegetable and animal oils and fats.

Lactic acid, highly destructive to concrete, is commonly associated with the handling of milk, buttermilk, and cheese, but is also present in various fermentation processes. Fresh milk will not attack concrete, but if allowed to collect in low spots on a concrete floor, or to penetrate the pores of the concrete, it sours and becomes acidic. Lactic acid then combines with the cement to form soluble materials which are easily eroded.

Frequent flushing of a smooth concrete floor with fresh water is desirable but once corrosion has begun small depressions are formed which collect milk and make cleaning more difficult. This condition is complicated further by the abrasive action of steel-wheeled carts which crush the concrete at the edges of depressions and expose more fresh surface to attack. In addition, some cleaning solutions used in dairies to clean milk containers are corrosive, so that a number of conditions can exist at once, all harmful to concrete.

Many large dairies find that the best method for overcoming the effects of lactic acid is to cover the concrete floor with a layer of natural quarry tile set in acidproof cement or putty. An alternative would be the use of hard burned clay brick preferably having a glazed surface, again set with acidproof joints. If bricks are used it is desirable that they be placed on end because steel-wheeled vehicles may dislodge them if they are laid in a horizontal position.

An exposed concrete floor is satisfactory in dairies if periodic replacement or resurfacing of the floor is considered economically practical. The frequency of replacement will depend both on the severity of exposure to lactic acid and on maintenance practices, but a floor receiving moderate to heavy usage may be expected to have a useful life of about eight to ten years. These floors require daily flushing with fresh water and should be constructed for heavy-duty service. This involves a surface in which no more than 5 gallons of mixing water is used per sack of cement (including free moisture in the aggregates), and for which the aggregates are clean,



The unprotected foundation of this farm silo shows clear evidence of attack by the acids present in ensilage.

sound, and carefully graded. The mix should be as dry as possible within the limits of workability. Compacting by rolling or tamping and floating with a power float are preferred. Curing after final steel troweling should continue for seven days when normal Type I cement is used.

Special cements are available to combat the growth of bacteria leading to the development of lactic acid, and successful results with them have been reported.* In addition it will be of benefit to seal the dry surface of cured concrete with such things as boiled linseed oil applied hot, cumar, or a high quality varnish.

Acetic acid, strongest of the organic acids, is encountered in such places as food processing plants and paper mills and on the farm in silos and on garbage feeding floors for hogs. Acetic acid combines with the hardened cement to form soluble compounds which, on removal, leave exposed aggregate. Household vinegar is ordinarily a 5 percent solution of acetic acid, but even a 2 percent or weaker solution can be injurious to concrete.

Floors subject to attack by acetic acid should be of heavy duty construction. Depending upon the degree of abrasion expected, coatings of hot paraffin wax, bituminous or coal tar paints or bituminous enamels may be used successfully. Tanks for storage of vinegar, or food preserved in vinegar, may require a glass lining set in acid-resistant mortar. Concrete silos on the farm will be subject to the effects of lactic and other acids in addition to acetic acid. Unprotected concrete will disintegrate slowly under these conditions and concrete silo staves may be expected to become quite rough after about ten years of service.

Application of either cement plaster or a cement wash to the interior of a silo after construction improves the durability of the concrete and greatly extends the service life of the structure. Cement plaster should consist of 1 part portland cement to 1½ parts of sand by weight. The sand should be graded so that all material passes the No. 4 sieve, from 15 to 35 percent is retained on the No. 14 sieve and from 65 to 85 percent is retained on the No. 48 sieve. The cement wash is merely a mix of cement and water having a creamy consistency. Both types of finish should be protected from abrasion and allowed to dry slowly for at least three days. Staves that become damaged with time may be renewed satisfactorily by grinding the roughened surface with a carborundum stone and applying a coat of plaster.

The garbage feeding floor is typical of cases where excessive abrasion makes almost any surface treatment ineffectual. Raw or cooked garbage is customarily dumped on this concrete slab and allowed to remain while hogs root for food. Periodically the floor is scraped clean with a metal blade having an abrasive action that destroys the effectiveness of any surface treatment. For this reason these floors are generally left untreated.

OILS

Vegetable and animal oils and fats have been known to lead to serious deterioration of concrete floors in such places as slaughter houses, processing rooms for lard and bacon, bakeries and in soap manufacturing plants. Both animal and vegetable oils contain some free acid when fresh, but the quantity increases with exposure to air. As with other acids, fatty acids combine with cement in the hardened concrete to form soluble compounds.

The degree to which oils of this kind attack concrete will depend to some extent upon the ease with which they can penetrate the material. Here both viscosity of the oil and permeability of the hardened cement are important. Quite frequently it is impractical to attempt to control viscosity but it may be used to predict the severity of attack in advance so that appropriate steps may be taken for control. For example, some vegetable oils may be expected to be more destructive than animal oils, merely because the latter become solid when cold. On the other hand, permeability of the concrete may be effectively reduced by lowering the water content of the mix as much as possible. This is accomplished by (1) uniform grading of aggregate with addition of sufficient fines; (2) use of the largest

*"Anti-Bacterial Cement Gives Longer Lasting Floors," *Food Engineering* June 1952, p. 57.

Careful observance of the basic principles of quality concrete work will assure the performance of the floor of this dairy barn.

possible maximum size aggregate; (3) use of the driest mix consistent with necessary workability and (4) use of entrained air.

The degree of attack will also depend, of course, on the amount of acid present; the higher the content the more rapid the action. In slaughterhouses, corrosion of concrete is severe and many of the larger packing plants use concrete only as a base material on top of which is placed a wearing surface of vitrified brick set in acid-proof cement. In areas where acid concentration is less severe, a heavy duty concrete surface is a minimum requirement, and this may be further improved by use of surface hardeners such as magnesium or zinc fluosilicate, or by application of oil insoluble resin. Bituminous treatments are not satisfactory because they are soluble in oil.

It may seem paradoxical that linseed oil, which is a vegetable oil, is frequently suggested as a treatment for sealing concrete surfaces from attack by various substances. Actually, linseed oil does attack concrete but when used as a protective treatment it is allowed to dry completely, and regular application of the fresh oil does not occur.

Mineral oils such as gasoline and naphtha, generally have no effect on hardened concrete. Lubricating oils are not harmful if entirely of mineral origin, but they are sometimes mixed with small amounts of vegetable oil and damage to concrete has been reported due to this cause.

SUGARS

Sugar affects both fresh and hardened concrete. In a fresh mix the presence of even small amounts of sugar will prevent the concrete from hardening and make it unfit for use. In one instance, for example, aggregates were shipped to a job in old sugar sacks which were not adequately cleaned. Grains of sugar clinging to fibers of the sacks were sufficient to prevent hardening, and after several weeks it was necessary to remove and replace the unsatisfactory concrete.

Dry sugar has no effect on hardened concrete but sugar solutions can be very corrosive. The problem is encountered in candy factories, food canning plants, and sugar refineries and in storing molasses, marmalade, and other sugar products.

One of the best forms of protection against attack from sugar solutions is to allow the concrete to become sufficiently hard by aging it for at least 28 days in air. During this period the calcium hydroxide in the hardened cement combines with carbon dioxide in the air to form a thin layer of calcium carbonate at the surface of the concrete. Hardened surfaces may also be achieved by application of chemicals such as magnesium fluosilicate which combines with cement to form compounds of increased hardness.

Coatings of tar asphalt are used with favorable results against sugar solutions. Storage tanks for concentrated solutions such as marmalade are best lined with glass or a similar material. High alumina cement offers more resistance than portland cement, but may not provide a permanent remedy.

COAL

Although the majority of concrete structures in contact with coal show no ill effects, deterioration has been noted in some coal storage bins and hoppers. Conditions necessary for this aggressive action are the presence of sulphur, usually in the form of iron sulfides (pyrites) and moisture. Anthracite coal, generally free of sulphur, is therefore not considered an offender. When sulphur and moisture are present they can combine, in the presence of oxyen, to form acids such as sulphurous or sulphuric. For this reason waste water from coal mines frequently attacks concrete structures in its path with devastating results.

If coal containing sulphur is to be stored, efforts should be made to exclude moisture. Roofing is preferable. The concrete should be dense and impermeable and surface hardeners such as the fluosilicates are recommended. Application of tar asphalt to the dry concrete will stop corrosion.

In general, the best insurance for durable concrete is close adherence to fundamental principles of quality concrete. The water-cement ratio should be low, entrained air should be added and the concrete should be well cured. These features, combined with special surface treatments when necessary, will greatly extend the useful life of any well designed structure. END

Laid directly on concrete without a vapor barrier either above or below, this wood floor was damaged beyond repair when excessive moisture caused it to buckle. This type of damage can be caused by the downward, as well as the upward, movement of water vapor. In general, vapor migration in the spring, fall and winter months tends to be upward from the soil, while through the summer months it is more often downward into the soil.

Vapor Barrier Materials

Most of the water vapor in the home gets in through the ground area beneath it, so the place to lick this expensive invader is in the foundation. This article explains the problem and tells about the materials that now enable us to combat it successfully.

FILE: AUXILIARY MATERIALS

ONE OF THE MOST DESTRUCTIVE of the forces that attack modern homes is a completely invisible and silent assailant called water vapor. Its ravages (measured by rotting timber, peeling paint, crumbling plaster, corroding metal and mildewed fabrics) cost American families untold hundreds of millions of dollars every year.

The problem has always been with us to some extent. But oddly enough the very things we have learned to do to the modern home to make it snug and economical to heat have aggravated the water vapor problem. We have found many ways to reduce heat transfer through walls, doors, windows and roofs (insulation, weather stripping, caulking, double glazing), but each move we have made has increased the certainty that water vapor concentrations will at times exceed safe levels.

Other factors also have tended to aggravate water vapor problems. Modern kitchens, bathrooms and laundries encourage the use of great quantities of water in the modern home, and this has necessarily meant a considerable increase in the amount of water evaporated each day. Add to this the tendency to build homes smaller, and thus to increase the number of occupants (and therefore the amount of vapor creating activity) per unit of volume, and it is fairly easy to understand why condensation has become the serious problem we know it to be.

Until fairly recently almost all the improvements we had made in home construction techniques and materials tended to make it harder for water vapor to escape, while little or nothing was done to discourage its entrance. Insulated walls and roofs, especially those incorporating barrier envelopes, deprive structures of the opportunity to breath, so that under many conditions it is inevitable that high humidity condi.ions will exist.

The real culprit in this whole picture has always been the area underneath the house. The ground area under the average home has been likened to an invisible spring which may produce as much as 20 gallons of water in the form of water vapor each 24 hours. This vapor passes through most building materials with complete ease, for it has only 1/205,000th of the density of water at 32 degrees F.

Compared with the 20 gallons of water vapor released UNDER the average house each day, the amount created INSIDE the house is a bare trickle. Studies of average families of four people indicate that all their activities (breathing, bathing, cooking and laundering) probably release about 3 gallons of water per day in the form of water vapor. So apart from the fact that it's impractical to call a halt to vapor-creating activities within the house, there's just naturally a lot more to be accomplished by diverting that ever-flowing spring under the house.

Fortunately a number of materials have been developed for the express purpose of providing impermeable barriers to vapor movements, and a fair share of these are apparently able to stand up well even under the very adverse conditions encountered in foundation work. Besides having a high resistance to the passage of water vapor, materials used for such purposes must be tough enough to withstand

Photo courtesy The Visking Corporation

A fairly newcomer to the vapor barrier family is polyethylene film, a plastic material that remains flexible at ordinary temperatures. It is unaffected by most acids, alkalies, bacteria and molds, and has a very low vapor transmission rate. In this photo a roll of Visqueen polyethylene film is being used to provide a vapor barrier between subgrade and a concrete slab which will be laid directly over the film. About $15 worth of film is said to be sufficient for an 1100-square-foot house. Joints may be sealed readily by means of portable electric tools, with pressure sensitive tapes, or with non-staining mastics. Polyethylene film weighs about 1/25 as much as 55-pound roofing paper, and costs only half as much. It comes in widths up to 32 feet.

The vapor seal material being placed here is called Premoulded Membrane. It is an asphalt hardboard composed of a core of high-melt-point asphalt in combination with mineral fibres and fine mineral aggregate. The core is sealed under heat and pressure between two dry liners of asphalt-impregnated kraft or felt. The material has a permeance rating of .0066 grains per square foot. In addition to being resistant to rot, mold and termites, it has the property of expanding and contracting with the slab above. The 4 by 8-foot sheets are laid directly over hard-tamped grade or fill with 6-inch head and side laps. The laps are sealed with an asphaltic compound.

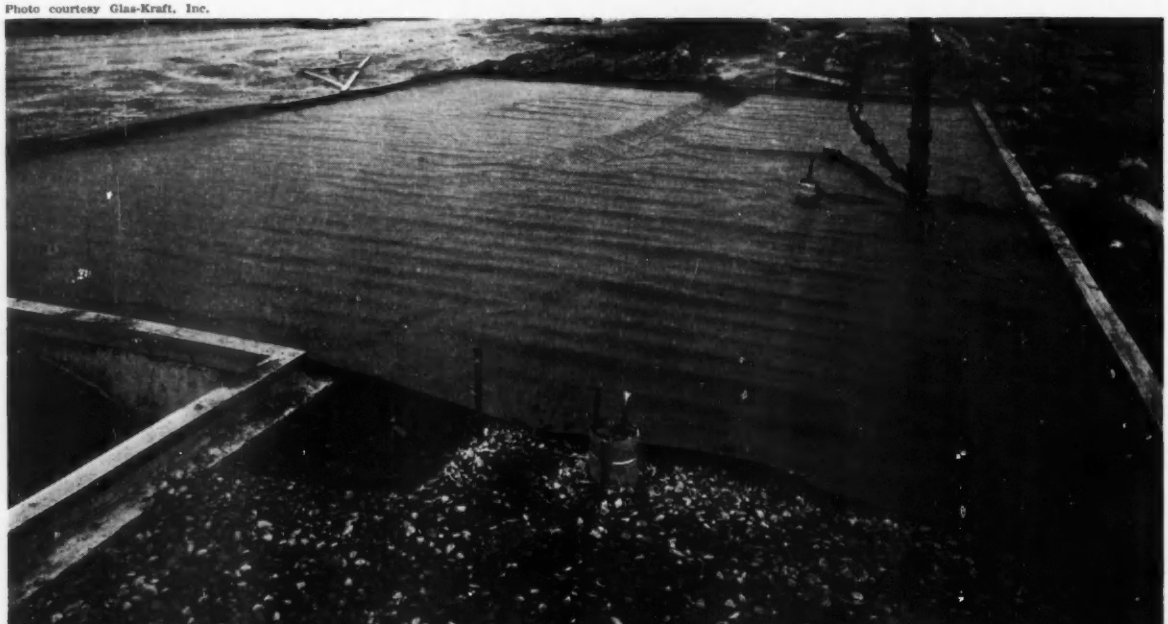
Photo courtesy W. R. Meadows, Inc.

Photo courtesy The Richkraft Company

In this view concrete is being placed over a subfill that has been covered with a vapor barrier known as Richkraft 65. This glass-fibre reinforced kraft paper comes in rolls with a choice of five widths (3, 4, 6, 7 and 8 feet). As you can see here, it is tough enough to withstand the heavy traffic usually involved in concrete pouring operations. Note that wire mesh reinforcement has been placed directly over the vapor barrier.

The vapor barrier material shown here is known as Rotbar No. 5. It is available in rolls from 18 to 96 inches wide, or in blankets up to 26 feet wide. Its strength is the result of bonding non-deteriorating glass fibres between layers of rot-proof paper. The resulting material, although light and therefore easy to handle, is tough enough so that it can be laid directly over sharp, coarse bases, such as the one shown in the photograph above. Note in the photo below how carefully the vapor barrier has been fitted around the service piping at the right. Before pouring the concrete for this slab-on-grade home, wire fabric reinforcement was placed directly over the vapor barrier.

Photo courtesy Glas-Kraft, Inc.



rough handling, water proof, absolutely inert, and able to stand up under assaults from acidic or alkali soils, insects or fungi. Ordinary building and roofing papers will seldom give satisfactory results in this type of service; unless a particular material has been designed for the severe conditions of below grade installation, the chances for satisfactory performance are slim indeed.

The variety of materials available today as vapor barriers is a tribute to the inventive ingenuity of American manufacturers. Papers, films, felts, plastics, metals, asphalts, glass and mineral fibres, and even mineral aggregates, have been combined in every conceivable way to make effective and durable vapor barriers.

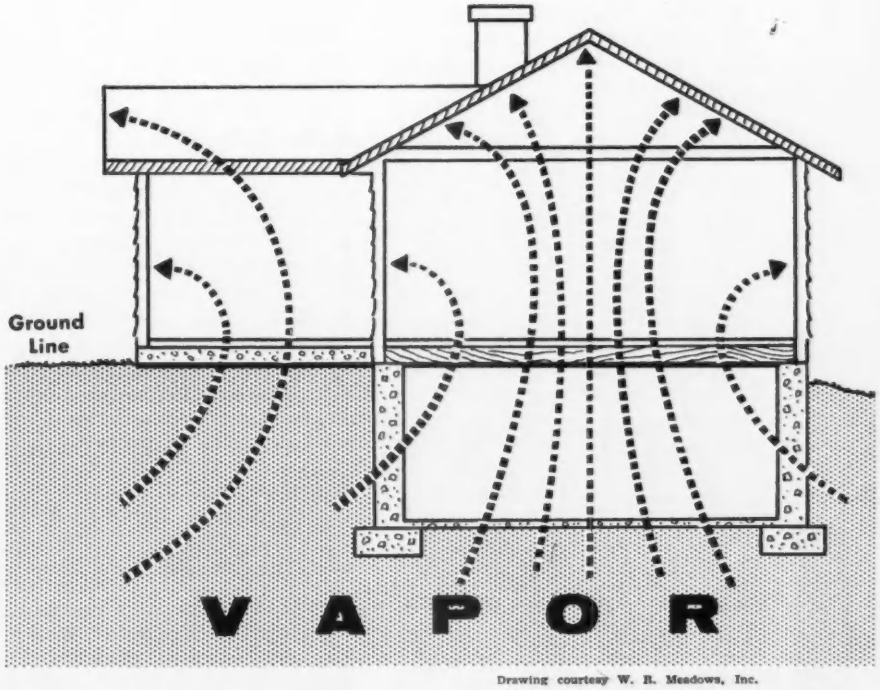
At the moment there are few criteria by which builders may evaluate and select a particular vapor barrier material among the many available. Test procedures for making definite evaluations have been spelled out in a study conducted by the Building Research Advisory Board, but none of the methods discussed in the BRAB report is likely to fall within the average builder's scope of activities. Until impartial studies have been conducted and comparative data made available, selection should probably be based on first hand experience and the known reputations of the several established manufacturers in the field.

In selecting and captioning the accompanying pictures, we have sought only to show a wide variety of the proprietary materials available. Inclusions and omissions do not represent any effort on the part of CONCRETE CONSTRUTION to reach a qualitative judgment.

We are bound to hear more about vapor barrier materials in the years ahead. Closely related as the problem is to foundation structures, we believe that concrete construction firms would be well advised to take the lead in urging wider use of vapor barriers as a means of solving moisture problems. Even though concrete is in no sense the culprit, we have an obligation to ourselves and the general public to disassociate ourselves from the problem by helping to solve it. END

Photo courtesy American Sisalkraft Corp.

Sealing joints on an installation of Sisalkraft Moistop, which consists of a sheet of pure polyethylene film laminated to a sheet of reinforced fungicide-treated Sisalkraft paper. On under-slab installations of this material the manufacturer recommends that all joints be lapped no less than 6 inches. Joints may be sealed with either a hot or cold mastic or sealing tape. The material comes in widths up to 8 feet. Its cost to the contractor is approximately 3½ cents per square foot.



Drawing courtesy W. R. Meadows, Inc.

Moisture migration from the ground area beneath a building into the structure itself goes on almost continuously unless a moisture-proof barrier of some sort is provided. The condition exists in all types of buildings—slab-on-ground, crawl space and basement. It probably accounts for more costly damage than all the ravages of fire, earthquakes and typhoons, and yet a few extra dollars spent on the installation of a vapor barrier at the time of construction can definitely keep this problem within bounds.

Some pros and cons of incorporation for contractors to weigh against the advantages of partnerships and proprietorships.

Is Incorporation to Your Advantage?

By William H. Allen, Jr., LLB.

FOR THE VERY REASON that partnerships so greatly outnumber corporations in the contracting business, one of the most frequent questions lawyers have fired at them by contractors is: "Should we incorporate?" Like almost all questions involving either business or law, there just isn't any simple clear-cut answer to this one. It depends on quite a lot of things. But here are some broad principles that should be understood by everybody who is likely to have to struggle with the thorny "to incorporate or not incorporate" problem.

Unless there is some good reason for incorporating it is probably not to your advantage. Organizing a corporation, or incorporating an existing business, is a fairly complicated procedure and may be rather expensive. A corporation cannot be created by the mere desire to do so, nor can it be brought into existence just by agreement of the parties, as is the case with a partnership. A corporation can be formed only by the authority of the government and by complying with the various provisions of the laws which govern the creation of the corporate business form. Without complying with these provisions it is impossible to incorporate, since by very definition a corporation is a creature of the law. It is a legal person and as such has certain rights and characteristics that set it apart from other types of business forms. These very rights and characteristics may make the corporate form advantageous for some small businesses, while at the same time rendering it a disadvantage for others.

Some of these rights and characteristics are as follows:

1. A corporation is perpetual. It is not subject to dissolution by death, withdrawal or legal disability of any of its individual shareholders. This permanency afforded by the corporate form may be important to your business. In a partnership or proprietorship when a partner or owner dies, the business must be reorganized if it is to continue.

2. A corporation has power to own and convey property both real and personal, and to enter into contracts, within the limits of its corporate charter just as if it were an individual.

3. It can sue or be sued in its own name.

4. The shareholders of a corporation are exempt from personal liability for the debt of the corporation beyond the amount of their shares in the corporation. A shareholder can lose only what he has put into the purchase of his shares. This can be a decided advantage. It can mean that even though your business goes on the rocks, your home, automobile, or other property would be exempt. They cannot be taken to satisfy the debts of the corporation.

5. The members of a corporation are not liable for the unauthorized acts of other members. The corporation may be liable but the individual members are not.

6. Shares of stock in a corporation may be sold to another person without affecting the corporate form or without the consent of the other shareholders. This means that any member of the business may sell his share and get out at any time without dissolving the business or without getting the consent of other members of the firm. This, of course, may be either an advantage or a disadvantage, depending upon circumstances. You can sell your share and get out without dissolving the business, but on the other hand you may find yourself associated in business with someone with whom you would rather not be associated. This makes very little difference in a large corporation, but it may make a lot of difference to you in your business.

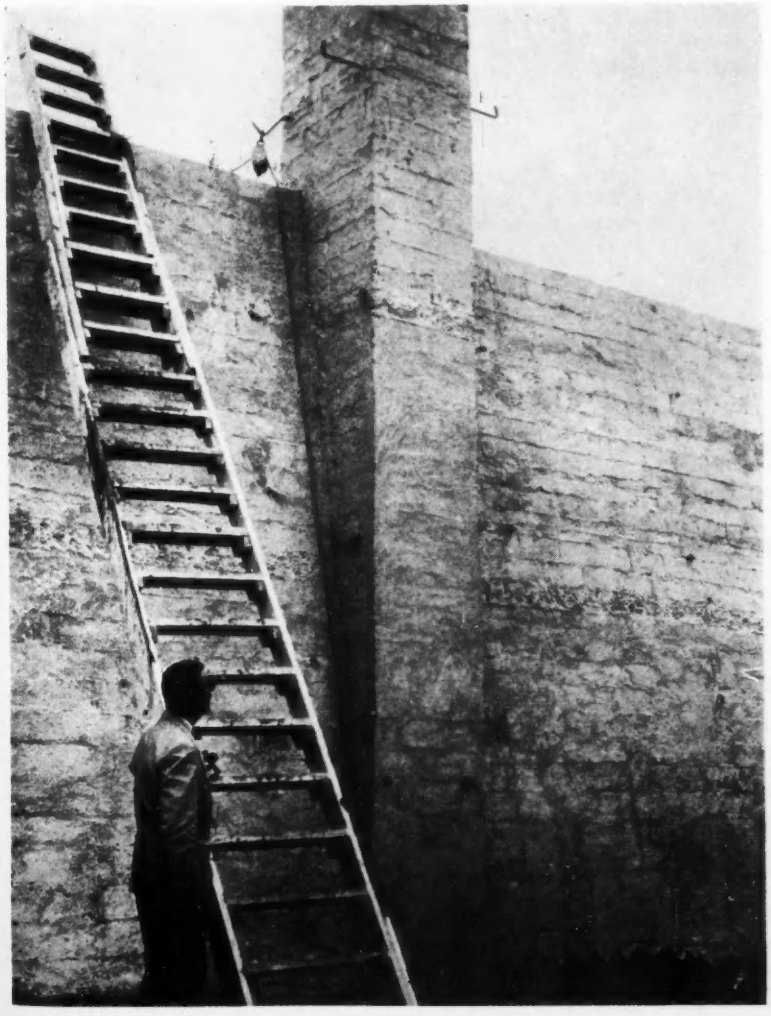
7. A corporation's board of directors rules by majority vote of the members of the board, whereas, as a practical matter, in a partnership the partners have equal say in the management of business affairs and as a consequence they must usually act unanimously. This may mean that even though you own most of the stock in your business, you may find yourself outvoted in a director's meeting by minor stockholders who are also on the board.

8. A corporation can sell stock and the corporate form is a greater inducement than either proprietorship or partnership for borrowing money or otherwise raising capital.

The effect upon Federal income taxes is often a decisive factor in deciding whether or not to incorporate. While each individual case should be decided on its merits, it is likely that a small business making modest profits will be better off from a tax standpoint if it operates as a partnership. Under most circumstances, this advantage gradually diminishses as it becomes possible to pay higher salaries to the principles and as profits increase. An experienced accountant can usually give you sound advice as to when the balance shifts enough to justify incorporating. END

Now it's Concrete Forms for Forming Concrete

Exterior view of reinforced concrete wall constructed by a new process developed in Puerto Rico. First a double wall of concrete block is erected and the concrete mixture is poured in between. When the concrete hardens, the block are removed leaving their imprint in the finished wall surface. The new system is said to be cheaper and more flexible than conventional methods requiring metal forms and scaffolding.



A NEW PROCESS developed in Puerto Rico makes reinforced concrete construction possible without the use of conventional forms and scaffolding. The method stresses simplicity to the exclusion of speed, and it is perhaps best adapted to areas in which labor is both plentiful and cheap.

First a double wall of ordinary hollow concrete block is laid up dry to any desired length and two courses high. Then plastic concrete, reinforced by wire mesh, is placed between the block walls. When the concrete has set two additional courses are added to the block walls, and the process is repeated in this fashion until the poured wall reaches the desired height.

When the final lift of poured concrete has set all the block are removed. The appearance of the finished wall is, of course, considerably rougher than an ordinary poured wall, since it retains the imprint of the block. The resulting rustic appearance is actually not at all objectional for many types of structures.

Several advantages are claimed for the block forming system. It allows for more flexibility in both the height and the thickness of the poured walls, and it is thus well adapted to the construction of large industrial buildings, warehouses and machinery foundations.

The same block may also be used over again for buildings of different designs, a feature which is said to make the new process cheaper than conventional forming, particularly when construction of a number of buildings of different sizes is involved.

The method was developed by Oscar Girod, an engineer with the Ponce Cement Company in Ponce, Puerto Rico. The company has adopted his technique in a number of its own buildings and the system is being used in other industrial construction throughout the Commonwealth. Other countries in the Caribbean area and Latin America are reported to be investigating the technique. END